Alternatives for Biological Resources in Africa[1]

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ABSTRACT

This paper calls attention to the fact that most of the current basic food items that feature in the diets of African homes were historically recent introductions to that continent. Attention is directed to the need for the development of the underexploited plants and animals that seem to have economic potential. The local sources of plant and animal proteins including fish proteins are discussed. Observations are made on the changing food habits of the people on the African continent. The need for substantial research in the biological resources of the continent are discussed.

Over the years I have become painfully aware of the fact that we in Africa have been making very little use of the biological resources available on our continent. In fact, the current use of only a few of the many biological resources with which Africa is endowed is a reflection of our inactivity in exploring the new and alternative resources of this magnificent part of the world. I would venture to say that since the Neolithic practically no new major food item emanating from the African flora has been added to the diet of the people.

I had the good fortune of being appointed the Co-Chairman of the U. S. Academy of Science's panel on "Underexploited Tropical Plants of Promising Economic Value" in March 1974. The work of the panel culminated in the gathering of an unbelievable amount of information on the many plants that people in the third world have not been using to their best advantage. The panel was charged with three main objectives: to identify neglected but seemingly useful tropical plants, both wild and domesticated, that have economic potential; to select the plants that showed the most promise for wider exploitation throughout the tropics; and to indicate the requirements and avenues for research that will ensure that selected plants reach their fullest potential.

I offer these same objectives to African scientists as a basis for seeking alternatives for the judicious exploitation of our biological resources.

Of the approximately 40,000 species of plants that occur in Africa, only a small number have been used throughout human history. Furthermore, of the handful of crops that form the bulk staples, a significant portion consists of plants that are not native to Africa. For example, the tropical root crop cassava (*Manihot esculenta*), an important carbohydrate source in the diet of many African people today, is a native of Brazil, from whence it spread to other

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parts of Latin America and the rest of the tropical areas of the world. The groundnut (*Arachis hypogaea*), which is rich in non-drying oil and protein as well as vitamins B and E, is also a native of South America. It was the Portuguese who introduced the plant from Brazil to West Africa in the 16th Century. The sweet potato (*Ipomoea batatas*), with its edible tubers and tender leaves, is likewise a native of tropical America. Ethnobotanical records show that the sweet potato was grown in Mexico and many parts of Central and South America during pre-Columbian times but was unknown in Africa, Asia, and Europe during the same period. The cocoyam (*Zanthosoma sagittifolium*) is a native of tropical America. Although the Portuguese and the Spanish had known about this plant, it was not until 1841 that missionaries from the West Indies introduced it to Ghana. Rice (*Oryza sativa*), which plays a very important role in the diet of Africa, traces its origin to southeast Asia. Once again it was the Portuguese who introduced rice into Brazil and West Africa. Maize (*Zea mays*) is undoubtedly one of the most important cereals in the African diet today. Like most of the above-mentioned cultivated plants, maize is not native to Africa. The plant was in cultivation in the New World during pre-Columbian times. Maize in its present form has never been found growing in a wild state anywhere. There is very reliable evidence that maize did not reach the Old World (including Africa) before 1492.

Of the commercially) important cash crops that are grown in Africa, cocoa (*Theobroma cacao*) is perhaps the most important—certainly for Ghana, Nigeria and the Ivory Coast. I hope you will not be too surprised to learn that, again, the cocoa tree is a native of tropical South America. The plant was introduced to the islands in the Gulf of Guinea in the 17th Century by the Spanish and Portuguese. A few cocoa pods of the Amelonado variety were taken to Ghana in 1879 from Fernando Po and, as you are all aware, these few pods gave rise to a very important industry in a major portion of West Africa. Another cash crop that features prominently in the industrial activity of some African countries is para rubber (*Hevea brasiliensis*). As its scientific name suggests, this plant originated in the tropical rain forests of the Amazon basin in South America.

I could go on and on citing examples of a number of other crops that are currently used in Africa but have their origins elsewhere. I do not want to leave you with the impression that Africa has not contributed something to other countries. For example, sorghum, which is of African origin, was introduced to China early in human history. This crop is now widely distributed in China because of the development of several local varieties. Nevertheless it is a sobering feeling to visualize what our dietary situation might have been on this continent if all the foreign crops I have mentioned were not available to us today. I feel uncomfortable even to think of the striking readjustments in our lives that would be necessary if we had not been exposed to all these introductions.

Why is it that throughout our history we have made but little use of our biological resources? The answer to this loaded question should be viewed from an historical perspective. During the colonial era very little attention was given to scientific research on the many indigenous plant and animal species that may be of promising economic value, because the consumer demands of the metropolitan countries of Europe were the principal determinants of the agrarian practices encouraged in the colonies. The scientific research institutes that were established in a number of African countries during the colonial era were slanted to fulfill specific missions. For example, many of the research organisations established by the British and the French in West Africa were mainly concerned with problems connected with the production of raw materials for export to the colonial and other European and North American markets. As I pointed out during my presentation to the West

African Science Association Conference here in Dakar some two years ago, the research efforts of the science institutes in Africa have not changed materially since the attainment of independence. The same mentality that guided research activities in Africa before political independence is being perpetuated today. Furthermore, several food items that were featured in the diets of Africans before the coming of the Europeans have been discarded gradually and replaced by kinds of foods that are readily acceptable to Europeans. It is only in relatively recent years that Africans have become proud to present indigenous dishes to their foreign visitors.

Apart from the colonial influence on agricultural research priorities in Africa, there is a fundamental attitude towards agriculture that separates, for example, the American Indian farmer from the African farmer. Historically the Central and South Americans of Mexico and Peru (to mention but two countries) were more interested in developing different strains of crops while their African counterparts were interested in the domestication of animals. And, as African civilization progressed, animals often became the equivalent of money, e.g. cattle culture in Rwanda.

Another limiting factor in the proper exploitation of our plant resources has been the quality of African soils. By and large, the soils of Africa are poor. You are all familiar with the typical weathering processes of our soils that often result in the formation of hard, reddish clay soils commonly known as laterite. Lateritic soils develop when the fertile topsoil is eroded away by the intensive rainstorms that expose the red clay soils underneath to the high solar radiation that often follows a big downpour of rain in the tropics. In the arid regions of Africa, wind erosion results in the removal of the fertile topsoil and renders the land unsuitable for efficient agricultural use. Over-grazing in certain parts of Africa has resulted in more serious abuse of the land than have other causes of soil erosion. The browsing habits of goats, for example, are very familiar to many of you. Until marked soil conservation measures are taken to safeguard the land, we cannot begin to think seriously about the efficient use of the limited suitable farmlands that are still available in Africa.

I think it is very important for us to understand that soil biology is a crucial component in the assessment of our biological resources because it is the basis of virtually all plant life, and hence all faunal elements depend on it as well. In a sense the soil is the most important biological medium since its composition includes both organic and inorganic substances. I need not remind you that our lack of knowledge of tropical soil was the principal reason for the Groundnut Scheme failure. It is, therefore, important that throughout our assessment of the biological resources of Africa, we bear in mind the state of our soils.

Plant Protein Production

When I began to reflect on the alternatives for biological resources in Africa, my mind immediately centered around the problems of protein production for food. Of all the possible sources for protein, I consider plants the most important. Plant proteins are basically cheaper than animal proteins. Let us first consider edible leaves of tropical origin. Proteins are first created in leaves. The process of photosynthesis is principally responsible for the creation of many intermediate reactions such as the production of keto acids. Briefly, soluble nitrogenous compounds and minerals are brought to the leaves where the ammonia portion is combined directly with the keto acids to form amino acids, which lead to the process of building-up of protein aggregates. From the standpoint of nutrition, there is no excuse for the diet of the African people to be short of proteins, because edible green leaves are abundant on the continent. The green leaves are rich in proteins but, in addition, they are physiologically important as regulators of the digestive tract. The green leaves also contain important

vitamin and mineral components that offer further enrichment to diets that are basically starch-based. Vitamin A is often found in large quantities in dark green leaves and is often resistant to the effects of cooking. Vitamin C, which is also present in leaves in appreciable quantities, often tends to be destroyed by cooking. Vitamin B, which is soluble in water, tends to be lost when cooking water is discarded. Other ingredients such as riboflavin and thiamine occur in reasonable quantities in leaves.

If I may digress a moment, just before I visited the People's Republic of China in July 1975, I was invited to dinner by the Chinese Ambassador in Ghana. At dinner several delicious dishes were served, including a wide assortment of green vegetables. The delectable qualities of the greens were so distinctive that I naturally paid the Ambassador a special compliment on them. The Ambassador quickly made the point that the green vegetables were all from Ghana. I was somewhat embarassed because I became distinctly aware of the lack of imagination that has surrounded our use of the vegetables that are readily available. I hasten to add that throughout my travels in Africa and other parts of the world, I have encountered a number of plant species whose leaves are accepted as edible. My plea is that a number of these green-leafed plants may be high protein sources, and therefore it is our responsibility as research scientists to investigate these plants for their nutritional importance both for human food and for animal feed.

In addition to the native plants that should be reviewed for their possible use, there are some important tropical plants that can be introduced to Africa which could assume the importance that, for example, maize, rice, cassava and groundnuts have achieved. The winged bean (*Psophocarpus tetragonolobus*) is a legume of far-eastern tropical origin with tremendous nutritional possibilities. In the recent report "Underexploited Tropical Plants with Promising Economic Value," it was described as follows: "The winged bean is a tropical legume with a multitude of exceptionally large nitrogen-fixing nodules. It produces seeds, pods, and leaves (all edible by humans and livestock) with unusually high protein levels; tuberous roots with exceptional amounts of protein; and an edible seed oil."

The winged bean has important potential for small-scale farmers. It is a fast-growing perennial that is particularly valuable because it grows in the wet tropics where protein deficiency in human diets is not only great but difficult to remedy. Winged bean seeds rival soya beans (*Glycine soja*) in oil and protein content, and the plant has the added advantages of protein-rich roots and edible foliage.

Though relatively unknown, this multipurpose legume appears to meet many dietary needs of the tropics.

I can forsee this legume assuming the same importance as soya beans in the very near future. After all, it was only fifty years ago that the soya bean became a prominent Asian crop, especially in China and Japan. Today, because of intensive agronomic research on the soya bean, it has become one of the principal crop plants in the world. When I visited Sri Lanka in June 1975 as a member of the U. S. Academy of Science's team that participated in a workshop on "Natural Products for Sri Lanka's Future," I discovered that the tender pods of the winged bean plant are delicious and heavily consumed in that country. The flowers, leaves, and shoots are eaten as vegetables. The stem of the plant serves as animal feed. Some varieties of this plant produce a fleshy tuber similar to the potato. It tastes very much like potato, and it contains 20% more protein. Its protein content is therefore 20 times that of cassava and certainly 10 times more than yams and other edible root crops.

I am delighted to inform you that to my knowledge the Agricultural Research Station of the University of Ghana and

the International Institute of Tropical Agriculture in Nigeria are already doing some work on this highly promising plant.

In addition to looking for new crop plants, it is essential that we do not lose sight of the limited uses to which we are currently putting the existing crops that feature in our diets. For example, a substantial portion of the cassava harvest in Africa is eaten boiled, roasted, or in the form of Gari. A certain amount of bulk cassava is used in preparing tapioca and starch. The potential for world market uses for cassava products is substantial. Apart from growing cassava for human consumption, two major markets have not been exploited to the fullest. The industrial starch market is still open. People often forget that cassava starch has found application in the manufacture of foodstuffs, textiles, and adhesives for stamps and envelopes, as well as newsprint, cardboard, gelling agents, fillings and munitions. The major markets for industrial starch include Japan, the United States and Canada. Because of the erratic supply of cassava starch from many developing countries (and this includes those in South America) the developed countries have been using only a small percentage of cassava starch in their manufacturing industries. If we can prove to prospective buyers that we are able to supply this needed raw material on a sustained basis and at competitive prices, I have no doubt that we can be assured of handsome financial returns.

The other use for cassava requires substantial quantities of pellets for the animal feed market. Several European countries are now using large quantities of cassava as a cheap source of carbohydrate for livestock. Many livestock production concerns have realised that it is relatively cheaper to prepare feed from cassava and soya beans than to use cereals. In fact it has been shown that an equal mix of cassava and soya beans is a feed superior to an equal mix of soya beans and maize. To my knowledge, Thailand is shipping large quantities of cassava chips to Europe. Obviously, because of our proximity to Europe and because of the large amount of marginal land available to grow cassava, the West African countries can develop a substantial market for this product.

Several other plants of tropical origin have been identified in the report on "Underexploited Tropical Plants of Promising Economic Value." I urge you all to take a look at the report and make use of as many of the recommended plants as possible.

Plants Containing Special Qualities

The exploitation of our biological resources should not be confined to only those plants and animals that feature in our daily diet. Some plants can indeed be exploited in external markets for sorely needed foreign exchange. In recent years it became obvious that the cyclamates used as a sweetening agent in a number of baby foods as well as soft drinks have some deleterious effects on man. It, therefore, became necessary to seek a sweetening substitute. After much experimentation in the United States and Europe, special interest was centered on the Miracle Berry (*Synsepalum dulcificum*), a West African plant. The pulp of its fruit obscures the sour taste of various food substances. As I pointed out in an earlier publication, Ghanian children often show great delight in impressing their friends that they can consume sour fruits such as lemon, lime, and grapefruit without expressing any distaste. This plant soon became a subject of intensive research in a number of American and European laboratories. The amino acid composition of the protein of this berry was soon worked out. The active principle of the berry was found to be a glycoprotein with a molecular weight of about 44,000. Soon after the labile glycoprotein was stabilized, and this enabled its use in a pill form as a sweetening agent. I must add that its use has not been confined to sweetening ordinary foods and drinks; it has also been used as a sweetener for diabetics. Imaginative

individuals in America and in Europe have taken advantage of the natural chemical properties of the berry only to enjoy vaginal secretions that change in taste from sour to sweet as part of their sexual amusement. The pills manufactured from this plant are known as the "Miracle Fruit Drops." The Miracle Berry plant is an economically important biological resource that should be exploited further. The plant grows in the wild in West Africa. It could easily be brought into cultivation and the harvest exported to pharmaceutical companies that manufacture the pills.

Medicinal Plants

Historically, plant-derived drugs have featured prominently in the treatment of all kinds of disease in Africa. The administration of the drugs has been in the hands of native herbalists. Plant species have been variously used to arrest convulsions, stop natural habitual abortions, cure syphilis, suppress chronic ulcers, remove warts on the sole of the foot, de-worm the afflicted, arrest asthma, serve as mosquito repellent, induce the flow of breast milk, etc. Over the years I have accumulated information on the uses of over 200 plant species from Ghana alone. No doubt several impressive lists could be obtained for other African countries.

Throughout the world today there is a serious shortage of supply of plant-derived drugs. Several of the drug-producing plants available in Africa can be developed into the basis of a highly sophisticated natural products industry. Some of the plants could be cultivated for the manfacture of end-product drugs or processed to yield compounds that, on chemical modification, can yield additional drugs. In some cases extractions could be made for use as primary starting material for the synthesis of several drugs. My own studies of yams (*Dioscorea* sp.) over the years have shown that the active principle diosgenin is not a useful drug by itself, but it is a starting material for the synthesis of most of the oral contraceptives on the market today. In recent years the plant *Fagara xanthoxyloides* has become a very important material in the cancer research programs in the United States. Other plants such as *Griffonia simplicifolia*, *Fagara macrophylla* and *Rauwolfia vomitoria* are being collected from the wild in large quantities for shipment abroad. The financial possibilities are endless. I will only remind you that, for example, in 1974 the United States of America produced great quantities of drugs derived directly from plants and sold them to the consumer to the tune of three billion dollars. This figure does not include the sales of antibiotics. I wish to emphasize again that a carefully planned screening program of the drug-producing plants will yield fantastic financial results for Africa.

Animal Protein Production

Throughout the history of Africa, the utilization of wildlife as a major source of meat protein has been significant. However, traditional hunting practice has led to a decrease in the populations of some of the choice game meats. In Ghana, for example, meat of the grasscutter (*Thryonomys swinderianus*) seems to get more and more expensive in the local open markets even if its availability seems to be quite normal. In fact, it has been observed that the more the supply of the grasscutter meat in the city markets, the higher the price. This observation simply means that the supply of this particular bushmeat is not meeting consumer demand.

There are several species of game animals that have proven to be good protein sources. In East Africa game animals such as the eland, impala, zebra, wildebeest, giraffe, duiker, warthog, steenbuck, waterbuck, buffalo, bush pig, elephant and kudu feature daily in the diets of many people. One of the game reserves I am familiar with is the Mole National Park in Ghana. The game animals I encountered there include hartebeest, buffalo, waterbuck, roan antelope, kob, bushbuck, oribi, duiker, warthog, baboon, patas monkey and green mon-

key. All these animals constitute substantial sources of protein if their numbers are allowed to swell and then cropped. Unfortunately, very few systematic attempts have been made to establish game ranches in order to maximize their production. From the few studies that have compared cattle and game animals, it is evident that the production of game animals generally outstrips that of cattle on all counts, especially if we take into consideration the marginal status of the available land and the carrying capacities of the various habitats for the two groups of animals. It is now a well-known fact that the effects of domesticated game animal grazing pressure on natural vegetation are less harmful than those of cattle and certainly more favorable than those of goats. Several detailed studies conducted on game ranches in East and South Africa have demonstrated that game animals can be supported without damage to grass cover and without any serious destruction of the soil. On the other hand, lands used for cattle ranching are almost invariably rendered useless because of the serious damage to the soil and vegetation. Different species of game animals graze and browse on different plant species within a habitat. Hence the presence of a variety of different game animals within one particular vegetation-type should not give cause for much concern. In a recent study conducted in the Serengeti-Mara Game Reserves, it has been shown that the two most abundant grazers in the reserves, the wildebeest and the Thomson's gazelle, manage to co-exist instead of competing for food. The wildebeest is a heavy grazer, and as it migrates across the Serengeti Plains it somehow stimulates the growth of the plant species that are exploited by the gazelle in the dry season. This clearly shows a co-existence between two heavy grazers which depend upon the same habitat for their survival.

Another important factor to consider is the fact that the total biomass of game animals living on low quality land is about equal the total biomass of cattle on a much better quality land. Furthermore, and perhaps most important, is the quality of protein produced by game animals as against that produced by cattle. Various studies on the nutritional value of bushmeat have shown that the quality of protein is at least as high as that of cattle. In addition, the vitamin content of bushmeat is much higher than that of beef, mutton, or pork.

Another advantage in favour of game animals, as a source of protein, is that less food energy is needed to bring their weight up before cropping. The amount of grain used in feeding cattle, sheep and pigs before they are slaughtered is being questioned by energy conservation minded persons all over the world today. It is, therefore, important that we seriously consider the feeding requirements of the conventional domesticated animals as against the natural feeding habits of game animals.

There is no doubt that the demand for bushmeat is increasing in many parts of Africa. It is, therefore, necessary that proper investments are made to infuse sophisticated management into game ranches so that those establishments can be self-sustaining and yet produce a greater quantity of protein.

As I intimated earlier, East and South Africa have had more experience in game ranching than has West Africa. In Botswana, for example, a number of game farms manage wildlife along with cattle on a sustained-yield basis. The Galana Game Ranch Research Project in Kenya was started in 1970 to explore the best methods for exploiting domesticated game. One of the Project's activities is the management of both game and conventional livestock under identical ranching conditions. In a screening programme, game animals such as the fringe-eared oryx, eland, buffalo, ostrich, and the Peters' race of Grant's gazelle have been herded with Boran cattle, small East African goats and crossbred Dorper, Masai, and Merino sheep. I have no doubt that this project is going to be successful in view of the quality of

the scientific manpower and institutions involved in the entire programme.

I also have learned that a proposed Nazinga Game Ranch Project for Upper Volta is being planned at the moment by the African Wildlife Husbandry Development Association of Canada and various agencies of the Upper Volta Government. If this project becomes a reality it will be the first well-planned game ranching project for West Africa. The practical information that will be derived from the proposed project undoubtedly will be of tremendous benefit to other West African countries contemplating similar projects.

In addition to bushmeat production, properly managed industries can be developed to handle the production of processed animal skins and trophies for sale. It seems logical that we can combine game ranching and sport hunting in our quest to seek substantial alternatives for the biological resources of Africa.

Fish Protein Production

No discussion of the biological resources of Africa can be complete without careful consideration of the fish fauna of the continent. We are all aware that fish is abundantly rich in high quality protein in addition to fat, minerals and vitamins. It is well known also that the nutritive value of fish is, in many cases, superior to that of beef and that it also is readily digestible and not easily denatured by cooking. For centuries our fishermen have exploited both marine and fresh waters. Based on earlier figures, I estimate that nearly 3.5 million metric tons of fish are currently harvested annually in Africa. Unfortunately, a substantial proportion of the catch is spoiled because of the lack of refrigeration facilities in most homes. Furthermore, because of the fish preferences of our people, several perfectly nutritious species of fish are not eaten. It seems obvious that with current techniques available in Africa, many of the unpopular fish, as well as the large quantities of perfectly desirable fish that are lost by spoilage, can be used in preparing fish protein concentrates for direct consumption by humans as well as in the preparation of fish meal for cattle and poultry feed.

In recent years a number of our coastal countries have been engaging in deep-sea fishing on a commercial basis. While on a recent visit to Japan, I was gratified to eat some prawns and shrimp that were of West African origin. However, certain foreign fishing fleets have been invading the territorial waters of Africa to the extent that if international agreements are not concluded soon most of the choice fish will be overexploited before Africa is ready to embark on a full-scale fishing industry.

In the case of fresh-water or inland fishing practices, many changes are necessary. In most cases, the fishing techniques of the Neolithic have not been improved upon. In areas where fishing techniques have improved, very little study has gone into the assessment of the fish populations in rivers, lagoons and lakes. As a result of our lack of knowledge of the breeding systems of the various species of fish in African inland waters, certain fish populations are being overly exploited. In a number of cases we do not know the species composition of many of the inland waters on the continent. I need not emphasize that a number of the natural and man-made lakes in Africa have tremendous potential for the production of fish protein if proper management principles are followed. Most of us are familiar with the importance of species of *Tilapia* in the diet of many peoples of East and West Africa. Unfortunately, our enthusiasm for eating this delicious fish has not been matched by our desire to study in detail all aspects of the biology of this fish, particularly its adaptation to pond culture. It is essential that if we want to derive maximum financial benefit from our fish resources, we must encourage systematic scientific research in all areas of fish biology.

Changing Food Habits

Seeking alternative biological resources for food, especially for home consumption, presupposes that the dietary habits of our people are not static, but are dynamic. Every society's food habits are governed to some extent by customs, traditions, and cultural beliefs. In some societies the taboos against certain foodstuffs are so rigid that even in the case of acute famine, the overly zealous would rather die than eat "forbidden" foods. Fortunately, most African societies are more flexible and capable of practical considerations in their eating habits than some of their Asian counterparts.

As I have indicated earlier, most of the major food items that feature constantly in our diets have been introduced into Africa. There are many Africans who cannot even accept the fact that plants such as cassava, corn, groundnuts and rice are foreign foods. On the basis of our past history, we already have the propensity to adapt to new food items.

In 1968 a book entitled "Food Composition Table for Use in Africa," was published jointly by the United States Department of Health, Education and Welfare (HEW) and the Food and Agriculture Organization of the United Nations (FAO). As its name implies, this work contains information on the protein, carbohydrate, mineral, vitamin and moisture content and the food energy value of many of the biological resources of Africa. The nutritive value of many plant and animal species has not been studied as yet. Nevertheless, this book is a good starting point from whence we could begin to take a hard look at the nutritive potential inherent in our biological resources.

Many of the food items discussed in the book are already being utilized in various sections of our societies. What is needed is the popularization of many of the foods not being utilized by introducing them into the commercial markets.

Summary

It is interesting to note that of the continents composed of developing countries, Africa is certainly the one in which most is known of its flora and fauna. The plant resources of Africa are certainly better known than those of South America. What is lacking is a rational asessment and utilization of the botanical resources of Africa. This is equally true of the level of our knowledge of the major faunal elements. Much work is needed to improve our knowledge of the biology of the small mammals and the lower plants.

Be that as it may, a number of our scientists (both pure and applied) and their administrative superiors are not even aware of the magnitude of and the potential inherent in our biological resources. It seems obvious that for African governments to obtain maximum utility from their biological resources, a concerted effort should be made to review the existing structures of scientific and technical organisations and to intensively review the native flora and fauna, so that their facility for solving problems and applying imaginative thinking to their research efforts can be realised to the fullest extent.

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